

Analyses of the Ash of the Normal and the Cataractous Lens

BY
WILLIAM EDWARD BURGE

A Dissertation

SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS
UNIVERSITY IN CONFORMITY WITH THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

1909

Baltimore

Reprinted from the ARCHIVES OF OPHTHALMOLOGY, Vol. xxxviii., No. 5, 1909

Analyses of the Ash of the Normal and the Cataractous Lens

BY

WILLIAM EDWARD BURGE

A Dissertation

SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS
UNIVERSITY IN CONFORMITY WITH THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

1909

Reprinted from the ARCHIVES OF OPHTHALMOLOGY, Vol. xxxviii., No. 5, 1909



Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41548215_0037

ANALYSES OF THE ASH OF THE NORMAL AND THE CATARACTOUS LENS.

By DR. W. E. BURGE.

(From the Physiological Laboratory of the Johns Hopkins University.)

THE following investigation forms a part of a larger series of analyses of the ash of different organs undertaken principally to ascertain what changes, if any, occur in the inorganic constituents of the tissues as a result of old age. Quite early in the work it became possible to get a large supply of human cataractous lenses in their capsules and it was thought desirable to study the changes that occur in the ash of the lens under these conditions. For the supply of cataractous lenses I desire to thank especially Dr. D. W. Green of Dayton, Ohio, who has been most generous in sending on many hundred of lenses exhibiting senile cataract and in many cases furnishing also the clinical histories of the cases. Through the kindness of Drs. Hugh Young and James Bordley, I was put in possession of a second large supply of similar lenses which had been collected in India by Dr. Smith. The abundant material thus obtained has facilitated greatly the work of obtaining satisfactory analyses, since certain difficulties were encountered, especially in the determination of the sodium, which required frequent repetitions of the analytical work. On the other hand, great difficulty was experienced in obtaining normal human lenses. The comparatively scanty material of this kind that it was possible to collect was obtained from time to time from autopsies. It was not, however, entirely adequate for the purposes of analyses and I

was obliged to make use of the pig's lens and many hundreds of the latter were used in the work, and the results from this source constitute the more reliable data as regards the ash of the young normal lens. It will be observed upon examination of the tables that the percentage of ash of the normal pig's lens is practically identical with that of the normal human lens. The analyses were directed to ascertain, first, the dry weight and the total ash of the lenses examined, and, secondly, to determine quantitatively the percentage amounts of the potassium, sodium, calcium, magnesium, and silicon in the ash. The methods finally found most useful in the process of ashing and in the analyses for the different bases named are described below in some detail. It may be said in general that the calcium was precipitated as oxalate in acetic acid solution and this precipitate was afterwards dissolved in dilute sulphuric acid and titrated with potassium permanganate. The magnesium was precipitated as ammonia magnesium phosphate and weighed as magnesium pyrophosphate. The potassium was determined colorimetrically by means of the method of Cameron and Failyer as modified by Howell and Duke.¹ In the determinations of the sodium the greatest difficulty was experienced. The methods usually recommended in the literature were found unreliable. The method usually described is to remove, first, the calcium and magnesium and then precipitate the phosphoric acid left in the filtrate by means of barium hydroxide or silver oxide, the excess of barium or silver being removed subsequently as barium carbonate or silver chloride. Assuming that these separations were successful, the residue remaining should consist only of potassium, sodium, and ammonia salts. The last can be removed by incineration and the potassium and sodium be weighed as chlorides. Since the potassium had already been determined by the colorimetric method, it should then be possible to determine the sodium by difference. Unfortunately these methods, although carried out with the greatest care, gave variable results and often the ash remaining, which was supposed to

¹ Howell and Duke, *American Journal of Physiology*, vol. xxi., February 1, 1908.

consist of only the potassium and sodium chlorides, weighed more than the initial total ash of the lenses used for the determination. The difficulty lay apparently in the fact that when the phosphates were precipitated with barium chloride the excess of barium could not be removed without using at the end some sulphuric acid and in that case it was not possible to get the potassium and sodium wholly converted to chlorides. When silver oxide was used instead of barium hydroxide it was equally impossible to remove satisfactorily the last traces of the silver. After many fruitless efforts to get concordant results for the sodium determinations, the method described below was used with success. In this method the phosphates were precipitated by barium hydroxide, the excess of the barium was removed with sulphuric acid, and the potassium and sodium, after removal of the ammonia by incineration, were weighed finally as sulphates instead of chlorides. From this weighing the amount of sodium present could be determined since the amount of potassium was already known. Examination of the literature, so far as it has been accessible or known to me, shows that very little previous work of this kind has been done upon the crystalline lens. The variations in weight and size of the lens have been recorded by several observers (Smith,¹ et al.). They have brought out the interesting fact that the lens increases in weight and volume throughout life, but, according to Smith, there is no change in the specific gravity. Dor² states that the old lens contains less water than in youth, but that in cases of cataract the percentage of water is increased. Deutschmann³ also states that in old age the percentage of water is diminished. Collins,⁴ on the contrary, reports that in the old lens there is an increased percentage of water. This last observer studied also the variations in the ash of the lens, although he made no effort to analyze the ash into its several constituents. He finds that the ash of a healthy lens is nearly constant, amounting to about 1 mg.

¹ Smith, *Royal Ophthalmic Hospital Reports*, vol. x., 1880.

² Dor, *Rev. d'ophth.*, April, 1907.

³ Deutschmann, *Gräfe's Arch. für Ophthalmologie*, xxv., 2, 1879.

⁴ Collins, *Ophth. Rev.*, viii., S. 321-331, 1889.

Cataractous lenses contain relatively less water and more solids and ash than the normal lens. In the analyses made during the course of the present work the methods have varied from time to time. The final procedure adopted has proved very satisfactory, and since it differs in some respects from that used in similar investigations it may be well to give a brief outline.

PREPARATION OF MATERIAL FOR ANALYSIS.

The lenses are put into weighed platinum crucibles, these are placed in an air-bath, and the temperature of this is kept at 110° for 24 hours. At the end of this time the crucibles are put, while still hot, under a desiccator and finally weighed when cold. This weight minus the weight of the crucible is taken as the weight of the dry material.

The platinum crucibles with the dry material are transferred to porcelain crucibles and these are placed over Bunsen burners; the heat must be very gentle at first, and be gradually increased until the platinum crucibles come to a dull, red heat. This heating is continued until a white ash is obtained. The crucibles are removed from the flame and allowed to cool. A few drops of hot water are added to the ash, the crucibles are placed in an air-bath at 110° and when dry are transferred to the sand-bath and from this to the Bunsen burners. If there is then any appearance of carbon the heating is continued until a white ash is obtained. The platinum crucibles are again placed, while still hot, under a desiccator and finally weighed when cold. This weight minus the weight of the crucible is taken as the weight of the ash.

METHODS OF ANALYSIS.

To the ash are added five drops of a twenty-five per cent. solution of hydrochloric acid and this acid solution is evaporated to dryness over the water-bath. This process is repeated three times. The residue is dissolved in water and made up to 100cc. Of this quantity 10cc are taken for the determination of the potassium and the remaining 90cc for the determination of the calcium and magnesium.

(A). The 10cc are evaporated to dryness in a platinum crucible, five drops of a 25% solution of hydrochloric acid are added, and six drops of a 10% solution of platinum

chloride. This solution is evaporated just to dryness over a water-bath at 70° . This dried residue is washed five times, by decantation, with 95% alcohol. Each wash is poured into a centrifugalizing tube. The crucible with the part of the precipitate left in it is dried over the water-bath. The centrifugalizing tube with the remaining portion of the precipitate is placed in the centrifuge and centrifugalized. The supernatant liquid is siphoned off and about 5cc of alcohol are added to the precipitate and again centrifugalized. This process is repeated five times. The centrifugalizing tube is then placed in a beaker of hot water until the residue is dried. The precipitate in the centrifugalizing tube and crucible are dissolved in hot water and combined. To this solution a few drops of a 1% solution of hydrochloric acid are added. After the solution is cool, fifteen drops of a 25% solution of potassium iodide are added. A red color develops. After about fifteen hours this solution or a known portion is diluted until its color matches as nearly as possible that of a standard solution containing a known amount of potassium. Then in order to make a more accurate comparison of the two solutions Schreiner's colorimeter is used.

(B). The remaining 90cc of the dilute hydrochloric acid solution are evaporated on the water-bath to a small bulk. Ammonium acetate, ammonium chloride, and a small excess of ammonium oxalate are added. The precipitate, calcium oxalate, is thoroughly washed with hot water by decantation and centrifugalization, and is then treated with an excess of dilute sulphuric acid. This acid solution is heated to 60° and titrated with a dilute standard solution of potassium permanganate until the fluid just shows a red tint.

(C). The supernatant liquid and washings from the precipitate of calcium oxalate are evaporated on the water-bath to a small bulk, a slight excess of ammonium phosphate is added, and the solution is then made alkaline with ammonia and set aside for twenty-four hours. The magnesium is precipitated as magnesium ammonium phosphate. This precipitate is washed thoroughly with ammoniacal water by decantation and centrifugalization. It is then transferred to a platinum crucible; the latter, with the lid on, is exposed for some time to a very gentle heat, which is finally increased

TABLE I.

This table gives the details of the analyses of the ash of the normal human and pig's lens for potassium, calcium, magnesium, and sodium.

Pig	Age	Tissue	Dry Mat. in Mgms.	Ash in Mgms.	K. in Mgms.	Ca. in Mgms.	K % in Dry Mat.	Ca. % in Dry Mat.	K. % in Ash	Ca. % in ash	Mg. % in Dry Mat.	Mg. % in Ash.	Ash % of Dry Mat.
"	About 1 year	1 Lens	141.90	3.18	1.07		0.75		33.64				2.24
"	"	5 "	676.00	17.20							0.17	1.51	2.24
"	"	5 "	740.80	16.40							0.18	1.71	2.32
"	"	5 "	674.20	16.00							0.14	1.35	2.37
"	"	3 "	438.10	11.10							0.06	1.11	2.33
"	"	3 "	410.90	10.03							0.06	1.29	2.43
"	"	8 "	1187.30	28.90							0.14	1.29	2.43
"	"	7 "	992.60	23.60							0.13	1.10	2.37
"	"	5 "	659.90	17.00							0.12	1.01	2.57
"	"	5 "	663.40	16.20							0.12	1.06	2.44
"	"	5 "	132.00	3.10	1.00		0.75		32.25				2.34
"	"	1 "	134.00	3.00	1.00		0.74		33.33				2.23
"	"	1 "	136.00	3.20	1.10		0.73		34.37				2.35
"	"	1 "	140.80	3.20	1.22		0.86		38.12				2.27
"	"	1 "	137.60	3.30	1.09		0.79		33.03				2.39
"	"	1 "	139.70	3.30	1.26		0.90		38.18				2.36
"	"	6 "	791.60	19.00	6.40		0.80		33.68				2.40
"	"	58 "	816.90	19.80			0.79		32.70	0.10			2.42
"	"	51 "	7830.70	189.40		0.208		0.002		0.09	0.025	1.06	2.41
"	"		7259.50	179.10		0.167		0.002			0.026	1.05	2.46

Pig	Age	Tissue	Dry Mat. in Mgms.	Ash in Mgms.	K. in Mgms.	Ca. in Mgms.	K. % in Dry Mat.	Ca. % Dry Mat.	K. % in Ash.	Ca. % in Ash.	Mg. in Mgms.	Mg. % in Dry Mat.	Mg. % in Ash.	Ash % of Dry Mat.
"	"	22 lenses	3028.70	81.85		0.066		0.002			0.868	0.028	1.06	2.70
"	"	54 "	7367.65	189.95		0.133		0.001 +			2.170	0.029	1.01	2.57
"	"	56 "	7748.30	179.05		0.133		0.001 +			2.150	0.027	1.20	2.31
Human	67	normal	81.00	2.05	0.827		1.02	40.36						2.53
"	67	"	75.90	1.90	0.802		1.05	42.23						2.50
"	24	"	50.00	1.10	0.545		1.09	49.54						2.20
"	24	"	50.00	1.10	0.527		1.05	47.90						2.20
"	65	Glaucoma.	69.05	1.90	0.617		0.89	32.50						2.18
"	25	"	45.75	1.00	0.301		0.65	30.08						2.15
"	35	"	54.80	0.85	0.294		0.52	28.00						1.55
"	35	"	55.80	1.05	0.294		0.53	34.58						1.88
"	42	"	64.65	1.80	0.731		1.13	40.61						2.78
"	42	"	43.00	0.85	0.366		0.82	43.05						1.97
"	0	2	33.10	0.85	0.222		0.67	26.03						2.56
"	0	2	34.25	0.45	0.127		0.37	28.22						1.21
"	0	2	31.30	0.40	0.159		1.20	39.75						1.27
"	0	2	25.15	0.35	0.103		2.40	29.42						1.39

TABLE II.

This table gives the details of the analyses of the ash of the cataractous lens (United States) for the potassium, calcium, and magnesium.

Human	Age	Tissue	Dry Mat. in Mgms.	Ash in Mgms.	K. in Mgms.	Ca. in Mgms.	K. % in Dry Mat.	Ca. % in Dry Mat.	K. % in Ash	Ca. % in Ash	Mg. in Mgms.	Mg. % in Dry Mat.	Mg. % in Ash	Ash % of Dry Mat.
"	70	cataract. lens	31.90	0.80	0.170	0.088				11.00				
"	70	"	59.95	1.00		0.143		0.27		14.30				
"	64	"	35.00	0.80	0.170			0.24	21.25					
"	70	45	1131.10	28.80		3.250				11.28	1.340	0.11	4.65	2.54
"	70	44	1173.95	22.25		2.940				13.21	1.324	0.11	5.04	1.59
"	70	10	445.00	5.20		0.881				16.94	0.347	0.08	5.67	1.10
"	70	10	533.90	5.40		0.971				17.80	0.520	0.10	9.67	1.01
"	70	10	423.30	4.70		0.813				17.30	0.477	0.11	15.12	1.11
"	70	11	461.20	5.60		1.056				18.35	0.282	0.06	5.03	1.11
"	70	00	433.80	3.80		0.695				16.34	0.282	0.06	7.46	0.87
"	70	00	370.20	3.90		0.621				17.81	0.347	0.08	8.86	1.03
"	70	71	377.20	3.80		0.599				15.76	0.521	0.13	13.71	1.00

Human	Age	Tissue	Dry Mat. in Mgms.	Ash in Mgms.	K. in Mgms.	Ca. in Mgms.	K % in Dry Mat.	Ca. % in Dry Mat.	K. % in Ash	Ca. % in Ash	Mg. in Mgms.	Mg. % in Dry Mat.	Mg. % in Ash	Ash % of Dry Mat.
"	67	cataract. lens	42.00	1.00	0.110	0.090	0.26	0.21	11.00	9.00				2.371
"	75	I "	44.20	1.20	0.110	0.097	0.24	0.21	9.16	8.08				2.71
"	64	nucleus "	22.00	0.50	0.099	0.045	0.40	0.30	18.00	9.00				2.27
"	64	cataract. "	51.65	1.50	0.102	0.100	0.31	0.19	16.25	10.60				1.93
"	78	I "	32.00	1.00	0.110	0.100	0.34	0.31	11.00	10.00				3.12
"	70	I "	34.20	1.12	0.102	0.100	0.29	0.29	9.10	8.92				3.27
"	70	I "	38.95	0.90	0.070	0.110	0.18	0.28	7.80	12.22				2.31
"	70	I 6	557.45	21.90	1.400	2.940	0.25	0.52	6.50	13.73				3.83
"	70	9	252.80	6.42	0.720	0.531	0.28	0.21	11.52	8.50				2.47
"	70	I "	23.80	1.25	0.080	0.137	0.32	0.57	6.66	11.49				5.04
"	80	I "	23.15	2.80	0.300	0.180	0.30	0.21	10.71	6.42				3.36
"	75	I 22	38.85	0.60	0.038	0.06	0.15	0.24	6.45	10.00				2.48
"	70	I "	34.70	0.80	0.028	0.09	0.09	0.24	3.16					2.91
"	70	I "	50.87	0.85	0.116	0.143	0.33	0.28	13.67	13.00				2.44
"	70	I "	50.87	1.10	0.057	0.10	0.10		3.45					2.16
"	70	I "	53.65	1.65	0.070	0.039	0.16		5.70					3.06
"	70	I "	52.75	1.00	0.051	0.07	0.07		5.13					2.96
"	70	I "					0.97							1.89

TABLE III.

This table gives the details of the analyses of the portion of the ash, soluble in dilute hydrochloric acid, of the cataractous lens (India) for the potassium, calcium, magnesium, and sodium.

Species	Age	Tissue	Dry Mat. in Mgms.	Ash in Mgms.	K. in Mgms.	Ca. in Mgms.	Mg. in Mgms.	Na ₂ SO ₄ and K ₂ SO ₄ in Mgms.	Na. in Mgms.	K. % in Dry Mat.	K. % in Ash	Na. % in Dry Mat.	Na. % in Ash	Ca. % in Ash	Ash % in Dry Mat.	Mg. % in Dry in Ash
Human		cataract. lenses from India	2288.25	33.90	2.04	2.17		32.00	8.14	0.09	6.01	0.35		6.40	1.48	
"	"	"	2288.25	33.90	2.00	1.96		32.20	7.88	0.09	5.81	0.34		5.80	1.48	
"	"	"	9283.40	147.10	10.86	7.35		152.30	41.05	0.11	7.38	0.44		5.00	1.58	
"	"	"	3206.50	83.50	2.60	3.58	0.97				4.85			6.09	1.6	1.81
"	"	"	3504.60	73.40	3.89	4.18	1.05				5.29			5.09	2.0	1.43
"	"	"	4310.70	70.90	4.00	5.04	1.18				5.64			7.10	1.6	1.66
"	"	"	4374.20	90.20	3.96	5.68	1.22				4.39			5.63	2.0	1.35
"	"	"	4782.10	81.00	4.82	5.53	1.40				5.95			6.82	1.6	1.72

TABLE IV.

This table gives the details of the analyses of the portion of the ash, insoluble in concentrated hydrochloric acid, of the cataractous lens (India) for calcium, potassium, magnesium, and silicon.

Dry mat. in Mgms.	Wt. of mat. insol. in con. HCl, in the ash in Mgms.	Wt. of Si, in the insol. mat. in Mgms.	Wt. of Ca, in the insol. mat. in Mgms.	Wt. of K, in the insol. mat. in Mgms.	K. % in insol. mat. of dry mat.	K. % in the insol. mat. of the ash	Ca. % in insol. mat. of dry mat.	Ca. % in insol. mat. of ash	Si. % in insol. mat.	Percent. of ash sol. in dilute HCl.	Percent. of ash insol. in concentrated HCl.	Per- cent. of Si. in ash
3206.50	8.60	1.54	0.17	0.82	0.02	1.53	0.005	0.31	17.90	83.92	16.08	2.87
3564.60	27.00	3.91	0.60	2.86	0.68	3.89	0.01	0.81	14.48	63.21	36.79	5.32
4310.70	12.90	2.26	0.23	1.20	0.02	1.09	0.005	0.32	17.51	81.80	18.20	3.18
4374.20	35.60	5.13	0.82	3.42	0.07	3.79	0.01	0.90	14.41	60.53	39.47	5.67
4782.10	18.20	2.70	0.35	1.90	0.04	2.33	0.007	0.43	14.83	77.53	22.47	3.33
5367.70	17.00	2.64	0.36	1.81	0.03	1.93	0.006	0.39	15.52	81.29	18.71	2.90
4679.10	11.40	1.67	0.23	1.18	0.02	1.52	0.004	0.29	14.64	85.23	14.77	2.16

to intense redness. The crucible is put, while still hot, under a desiccator, and finally when cold the magnesium is weighed as magnesium pyrophosphate.

(D). The supernatant liquid and washings from the precipitate of ammonium magnesium phosphate are evaporated on the water-bath to a convenient bulk, a slight excess of baryta water is added, and the solution is boiled. This precipitate is thoroughly washed with warm water by decantation and centrifugalization. The original liquid and washings are evaporated to a few *cc* and the barium removed with sulphuric acid. The precipitate, barium sulphate, is thoroughly washed by decantation and centrifugalization. The supernatant liquid and washings are evaporated to a small bulk poured into a platinum crucible, and evaporated to dryness over a water-bath. The ammonium salts are removed by ignition at a low red heat. A few drops of a 5% solution of sulphuric acid are added to the residue, which is then evaporated to dryness and heated to a very dull red heat to drive off all free sulphuric acid. The crucibles are put, while still hot, under a desiccator and the alkalies, sodium and potassium, are weighed as sulphates. The potassium in this residue was determined by the method previously described, and the sodium was obtained by the difference. The determinations of the potassium made in this residue agreed very well with those made upon an aliquot part of the solution of the original ash (A).

RESULTS.

The main facts brought out by these analyses may be presented briefly in the following table, which gives the average results as estimated for a single lens.

	Average dry wt. of one lens	Average wt. of ash of one lens	Percent. wt. of ash to dry wt.	Percent. of K. in ash	Percent. of Ca. in ash	Percent. of Mg. in ash	Percent. of Na. in ash	Percent. of Si. in ash
Normal adult human lens.	58.99 mgr.	1.40 mgr.	2.30	38.80	?	?	?	0
Normal adult pig's lens	137.70 "	3.40 "	2.45	34.30	0.08	1.20	6.67	0
Embryo human lens	15.47 "	0.25 "	1.60	30.80	?	?	?	0
Cataract human lens (United States)	34.42 "	0.58 "	1.68	9.80	12.50	8.00	23.82	0
Cataract human lens (India).	92.30 "	1.52 "	1.64	5.81	6.00	1.6	25.06	3.63

On the basis of these figures the following general conclusions may be drawn.

1. In the human cataractous lens (senile cataract), the percentage of potassium in the ash is greatly reduced, while the percentages of calcium and sodium are greatly increased, as compared with the normal lens. In the lenses obtained in the United States, there was also a distinct increase in the magnesium in the ash, while in those from India there was a notable amount of silicon. It will be noted that no figures were obtained for the calcium, magnesium, or sodium for the normal human lens, owing to the difficulty in getting this latter material. It is certain, however, that in the normal human lens the calcium and the magnesium exist in very small amounts, as proved by quantitative reactions, and although the amounts were too small for quantitative determination it seems most probable that they are of the same order as in the normal pig's lens. Sodium determinations were not made for the normal human lens, since at the time that this material was being analyzed a satisfactory method of determining sodium had not been obtained. For this element also it is necessary in the comparison with the cataractous lens to use the figures obtained from the pig's lens. In regard to the cataractous lenses obtained from India (Dr. Smith), we have the additional peculiarity of the presence of a distinct amount of silicate of calcium and potassium and possibly sodium. In the cataractous lenses obtained from the United States (Dr. Greene), silicates did not occur, or at least did not occur in quantities sufficient for determination. The ash of a large number of these lenses was either completely soluble in dilute hydrochloric acid, or if any residue remained it was so minute as to be beyond the possibility of analysis. What conditions cause such a marked deposition of silicates in the cataractous lens of the inhabitants of India can not be stated. The natural suggestion is that there may be some peculiarity in the diet to account for the silicate, and it would be interesting to ascertain whether other organs or the liquids of the body in these individuals also contain notable amounts of silicates.

2. It is worthy of special comment that the changes in the ash of the cataractous lens are of such a character as to

bring it more closely in connection with the composition of the blood and lymph. That is to say, in cataract, the lens loses the characteristic ash content of a living tissue and approaches the composition of the liquids of the body to the extent that its content in potassium is diminished and its content in sodium and calcium is increased.

3. The figures for the cataractous lens indicate that as compared with the normal human lens it contains less organic material and less percentage of ash. Unfortunately, no figures were obtainable in regard to the average total weight and water contents of such lenses, but if Collins is correct in stating that the cataractous lens has in general a higher percentage of solids and ash in reference to the total weight, the figures obtained in my analyses can only indicate that the total weight of the cataractous lens must be smaller than that of the normal lens.

4. As between the normal human lens and the normal pig's lens it is interesting to note that although the pig's lens is much larger and heavier and contains much more solid material and ash, nevertheless the percentage of ash is identical in the two cases, and so far as the analyses were carried the composition of the ash is apparently the same.

5. It was hoped in the beginning of the work that sufficient normal human material might be obtained to furnish data in regard to the changes in ash content, if any, with increasing age. As a matter of fact, a quantitative estimation of the ash in the normal human lens was possible only for the potassium, and so far as this element is concerned the analyses indicate that there is no change with age. The lens in old age as compared with the lens in the embryo shows certainly no diminution in potassium, and most probably there is no increase in calcium or magnesium, since in the old as in the young lens these elements are present in such small quantities as to make a quantitative determination impossible, unless a very large number of lenses are used. On the basis of these facts, one may conclude that the lens in the very old (70 years) shows no such evidence of senility, when judged by its mineral constituents, as is seen in some other tissues, the arteries, for example, and this conclusion falls in with the known fact that the lens, unlike most of the organs, continues to grow through-

out life. This fact would also indicate that it is a mistake to assume that senile cataract is an instance of premature senility in the lens, that is to say, that it is simply an acceleration of a normal senile change. On the contrary, the evidence, so far as it goes, would indicate that senile cataract when it occurs is due to some cause which has interrupted the normal metabolism and brought on a moribund condition of the lens tissue.

6. It will be noted that in the lens of the embryo the total solid material is small and the percentage of ash is also small. The growth of the lens that is known to take place throughout life is indicated by the few figures in the table which give the weight of solid material at different ages.

7. In Table IV. it will be noticed that 76.21 per cent. of the ash of the lenses obtained from India was soluble in dilute hydrochloric acid, and that 23.79 per cent. was insoluble in concentrated hydrochloric acid. This insoluble portion of the ash was analyzed for magnesium, silicon, calcium, and potassium. No magnesium was found. Silicon was present to the extent of 15.61% of the insoluble material, calcium to 0.49 % of the total ash, and potassium 2.38% of the total ash. Hence, in these lenses there are present silicates of calcium and potassium and possibly of sodium.

Tables II. and III. show that the percentage of calcium and potassium in the ash of lenses obtained in the United States is greater than that in the ash, soluble in dilute hydrochloric acid, of the lenses obtained from India. However, if the amount of calcium and potassium found in the silicate of the ash of the Indian lenses be combined with the calcium and potassium content of the part of the ash soluble in dilute hydrochloric acid, then the percentage of calcium and potassium in these lenses is found to be about the same as that of the lenses from the United States.

SUMMARY.

1. There is a decrease of potassium in the cataractous lens from 38.8% of the ash in the normal to 9.8% in cataract.

2. The calcium in the cataractous lens increases from an almost negligible quantity in the normal to 12.5% in cataract.

3. There is an increase in the magnesium in the cataractous lens obtained in the United States from 1.20% as estimated in the pig's lens to 8.00%. This increase is therefore not so marked as the increase in the calcium.

4. Assuming that the sodium in the normal pig lens is about the same in quantity as the sodium in the normal human lens, then the increase in sodium is practically of the same extent as the decrease in the potassium, the sodium increasing from 6.67% in the normal to 25.06% in the cataractous condition.

5. The lenses obtained from India differ from those obtained from the United States in that they contain a large amount of calcium potassium and possibly sodium silicate, and fail to show any increase in the percentage of magnesium in the ash.

At this place I desire to thank Professor W. H. Howell, at whose suggestion this work was begun and under whose direction it has been carried on, for his kindly criticism and interest.

LIFE

William Edward Burge was born in Lynchburg, Va., September 17, 1880. He received the degree of A.B. from Randolph-Macon College, Virginia, in 1903, and A.M. from the same place in 1906. In October, 1906, he entered the departments of Biology, Physiology, and Physiological Chemistry of the Johns Hopkins University, where he studied under Professors Jennings, Howell, and Jones.

